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Relationship between age-related decline of cognitive functions and willingness to work using a computer

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Abstract

This study clarifies relationships between cognitive functioning and older adults' willingness to work using ICT equipment. Sixty-six workers, 60 - 79 years old, participated in a survey measuring cognitive functions (working memory, visual attention, and task-switching) and ICT literacy and willingness to work using a computer. The results of statistical analysis (structural equation modeling) indicated that ICT-related experience affects willingness to work with a computer, and that experience with ICT equipment is negatively influenced by age-related decline in task-switching. This result suggests that compensating for the decline of task-switching ability by improving the design of the interface of ICT equipment is necessary for a workplace that is often staffed with older adults.

Keywords: cognitive aging, ICT equipment, older adults, usability

1. ICT Use and Cognitive Aging

The rapid growth of the elderly population is increasing financial pressure on governments in many advanced nations. As a result, some governments have begun to increase the population of elderly people who work by raising the retirement age[1]. Information Communication Technology (ICT) has been introduced for assisting workers and promoting efficiency[2]. Accordingly, there are more opportunities

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that require older adults to work in a computerized workplace. However, many older adults have difficulty in a computerized workplace because they are not able to efficiently use ICT equipment. Therefore, it is important to redesign the workplace by focusing on usage of ICT devices so that older workers can work as efficiently as younger workers.

In many countries the utilization rate of ICT equipment by older adults is lower than for younger adults[3][4][5][6]. Older adults' lower computer use is also seen in workplaces, and affects their work performance[7][8]. For this issue, many reports indicated that age-related decline of cognitive functions is one cause of older adults' low ICT use (e.g., Czaja et al.[9]). Based on these findings, Hawthorn[10] suggested improving the usability design of the interfaces of ICT equipment by focusing on the relationship between age-related decline of cognitive functions and ICT use. In order to make ICT equipment easier for older adults to use, it is important to identify those cognitive functions where decline negatively affects ICT use. This approach is probably useful in addressing the problems that older adults face in a computerized workplace. However, most studies have focused on individual ICT operations used in daily living; few studies have focused on older adults' working with ICT equipment. Our study focuses on comprehensive ICT use that is thought to be related to work (e.g., desktop computer use and Internet use). In addition, the willingness of 60 to 79 year-old workers to work using a computer was examined. The purpose of this study is to clarify relationships between cognitive functions, comprehensive ICT use, and willingness to work using a computer.

2. Method

2.1. Participants

Sixty-six older working adults (29 men and 37 women; age M = 69.57 years, SD = 4.88) were recruited from a staffing service organization and paid for their participation. The experimental protocol was approved by the ethics committee of the University of Tokyo. All participants gave informed consent.

2.2. Procedure

A questionnaire survey was conducted in March and June 2010. Participants gathered in groups of about 20 in a quiet room. First, they were asked to fill out a consent form. Next, they answered the questionnaire. Finally, they completed a questionnaire-style cognitive test. All participants could finish this survey in an hour.

2.3. Materials

The Advanced Industrial Science and Technology's Cognitive Aging Test (AIST-CAT) was used for measuring participants' cognitive functioning. The AIST-CAT test battery of eight tasks was developed for measuring mild age-related decline of cognitive functions in healthy older adults who are considered neurologically normal[11]. This study used four of these tasks: working memory (WM), visual selective attention (VA), task-switching (TS), and planning (PL).

For the WM task, 24 Japanese "hiragana" letters were printed as sample letters on a test sheet. Participants had to copy a mirror image of each normal letter into a space to the left of the given sample letter. They were asked to do as many letters as possible within 1 min. For the VA task, 36 target shapes and 132 distracters were printed on a test sheet. A frame outlined the search area; above the frame there was a target shape as a sample. Participants were asked to check as many specific instances of the targets as possible within 1 min. For the TS task, there were 48 items on a sheet. Each item consisted of two digits printed in different sizes, with a Chinese character between them that meant "shape" or "number". When the Chinese character was "number," participants had to select the digit that was numerically larger (e.g., 4 is larger than 3). When the Chinese character was “shape,” they had to select the digit printed in the larger typeface. The time limit was 1 min. For the PL task, participants were required to fill in the blanks inserted into procedures for sending a letter, from "write a letter" to "post a letter". A motion task was also conducted to measure the motion abilities of the participants. For each cognitive task in the AIST-CAT, z-scores were calculated using previously established norms from 308 older adults (151 men and 157 women; age M = 72.04 years, SD = 5.45).

A questionnaire related to ICT use was also administered. It contained items as follows: ICT-related knowledge, ICT-related experience, and Aikyodai’s computer anxiety scale (ACAS)[12]. ICT-related knowledge consisted of 16 words such as “mouse” or “keyboard.” The number of words that a participant knew was scored. ICT-related experience consisted of 11 questions about PC use and Internet use such as “Have you ever made documents with a computer?” The number of items that a participant answered “yes” was scored. In this study, ICT-related knowledge, ICT-related experience, and ACAS are referred to generically as ICT literacy.

Two items related to willingness to work were also included: “I do not want to work anymore”; and “I want to work with a personal computer”. A 6-point Likert scale ranging from 1 (strongly disagree) to 6 (strongly agree) was used to rate each item. Reverse scoring was conducted for the first item to represent positive willingness to work.

3. Results

3.1. Characteristics of participants

Percentage of computer use of participants was 87.8% (aged 60-64), 78.6% (aged 65-69), 68.1% (aged 70-74), and 55.8% (aged 75-79). Percentage of internet use was 87.8% (aged 60-64), 62.8% (aged 65-69), 59.6 (aged 70-74), and 34.9% (aged 75-79). These percentages are higher than Japanese averages: 56.0% (aged 60-64), 41.2% (aged 65-69), and 26.9% (aged 70-79) for computer use; and 71.6% (aged 60-64), 58.0% (aged 65-69), and 32.9% (aged 70-79) for internet use [13]. Average of education years of participants was 14.0 years for men and 12.9 years for women. It is also higher than Japanese averages: 12.0 for men and 11.1 for women [14].

3.2. A factor model of older adults’ willingness to work using a computer

First, relationships among the basic variables were examined using SEM (structural equation modeling). There were two variables for willingness to work. One represented willingness to work in general, and the other represented willingness to work using a computer. We expected that general willingness to work also includes some component of willingness to work using a computer. In addition, we expected that willingness to work using a computer is affected by ICT literacy. SEM was conducted based on this hypothetical framework, which resulted in a valid model (Fig.1-(a)). Indexes of goodness of fit were: CMIN/DF (chi square/degree of freedom ratio) = 0.922; GFI = .970; CFI = 1.000; and RMSEA = .000. Criteria of these indexes for an acceptable model are: CMIN/DF < 2; GFI > 0.9; CFI > 0.9; and RMSEA < 0.1[15][16][17][18]. All indexes of goodness of fit for this model satisfied these criteria. In addition, all paths were significant ($p < .05$). Thus, the hypothetical framework presented above was supported.

Next, the effects of cognitive functioning on the model (Fig.1-(a)) were examined. The relationships between the cognitive functions and the other variables were examined using the z-scores of the four cognitive functions. We hypothesized that these cognitive functions independently affect ICT literacy or willingness to work. However, the most valid model obtained (Fig.1-(b)) was not acceptable (CMIN/DF = 2.909, GFI = .806, CFI = .730, RMSEA = .171). The path between task-switching and ICT-related experience was significant ($p < .05$), whereas the other paths related to cognitive functions were not

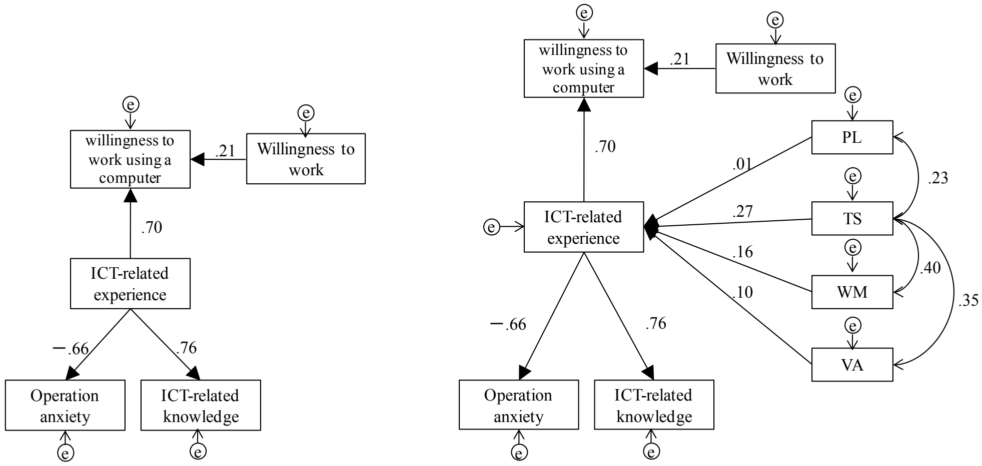

Fig.1. (a) A basic model that contains variables of willingness to work and ICT literacy; (b) A model that hypothesized independent influences of each cognitive function

significant. Taking this result into consideration, new paths were assessed by focusing on task-switching because it was the only cognitive function that directly affected ICT-related experience. We expected that TS includes WM and VA because it is necessary to remember the task sets and to pay attention to the cue for switching the task. Therefore two paths from WM to TS and from VA to TS were hypothesized. In addition, effects of age, years of education, and motion ability were added to the model. As a result, an acceptable model was obtained (Fig.2). Indexes of goodness of fit were: CMIN/DF = 1.138; GFI = .88; CFI = .970; RMSEA = .046. Although the GFI was slightly lower than the standard value, the other indexes showed acceptable values. In addition, all paths were significant ($p < .05$). This indicates that ICT-related experience is directly affected by TS, and is also affected by WM and VA indirectly via TS. In addition, this indicates that there is a significant correlation between PL and TS, and also that the effect of TS on ICT-related experience is stronger than the effect of PL.

4. Discussion

This study clarifies how ICT literacy and cognitive aging affect willingness to work using a computer, and raises the possibility of supporting older adults' work by redesigning the ICT environment.

The result of SEM (Fig.2) shows that willingness to work using a computer is influenced by ICT-related experience and general willingness to work. Path coefficients indicate that ICT-related experience is the main factor of willingness to work using a computer. ICT-related experience is mainly affected by task-switching. These results indicate that an older adult whose task-switching ability has not declined tends to have a relatively higher willingness to work using a computer. Looking at this from another perspective, age-related decline of task-switching ability makes it difficult for some older adults to work with computers. This relationship between ICT literacy and task-switching can be interpreted as follows. Persons with higher task-switching ability can adapt well to using ICT equipment. As a result, they can obtain ICT-related knowledge and reduce their computer anxiety. In contrast, persons with lower task-switching ability have difficulty with using ICT equipment. This negative experience increases their computer anxiety and stops them from acquiring new ICT-related knowledge. The model also shows that age negatively affects cognitive abilities of working memory, visual attention, and indirectly task-switching. Participants in this study had been educated longer than average older adults in Japan probably because they were inhabitants of urban areas. Besides, percentage of computer use and internet use was

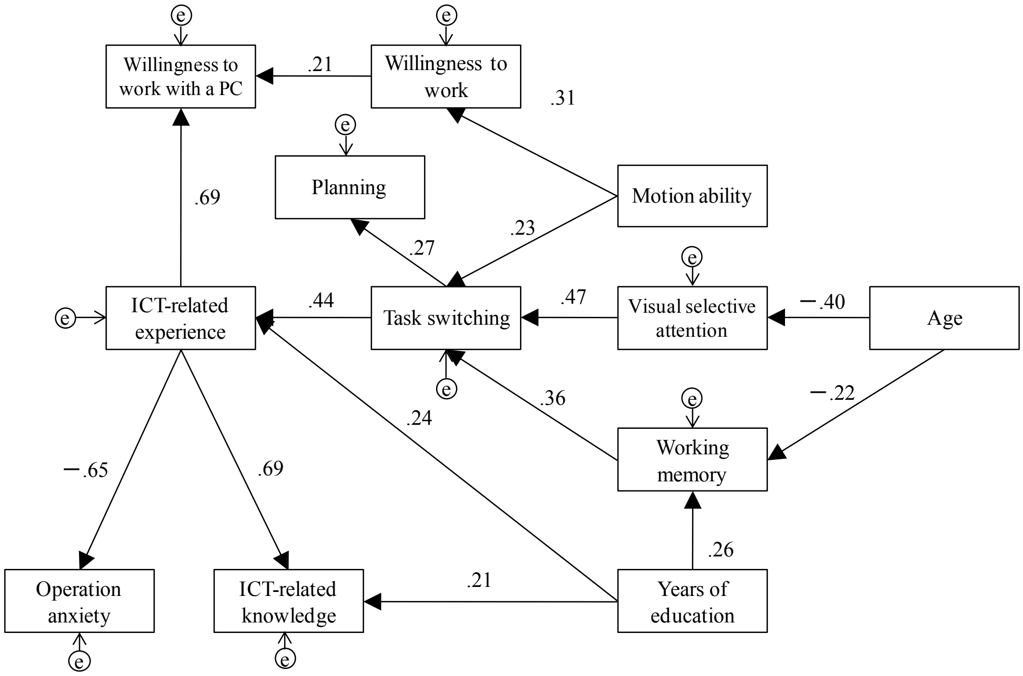

Fig.2 A final model that consists of willingness to work, ICT literacy, and cognitive functions

also higher than the average of older adults in Japan. These facts are explained by this model which indicates the years of education raise ICT-related knowledge and ICT-related experience.

The obtained model was made up of one-way relations of cause and effect because SEM merely represents acceptable relationships among the present variables. However we assumed that these causal relationships are part of a loop in long-term interactions. That is, ICT literacy and cognitive abilities mutually interact. For example, Tun and Lachman[19] found correlations between the frequency of using a computer and task-switching ability. They interpreted their results in the opposite direction from our findings, as showing that task-switching ability was bolstered by using a computer. In addition, Spitzberg[20] also assumed interactions between causes and outcomes in their model of computer-mediated communication. By applying these conceptualizations to our study, cause and effect relations can be considered to make up a loop. The decline of task-switching reduces opportunities for using ICT and the reduction in the frequency of using ICT causes further decline of task-switching ability. In this loop, the age-related decline of task-switching could be a trigger of a vicious cycle.

We anticipate that this problem can be resolved by redesigning ICT equipment. The model shows that existing ICT equipment places a heavy load on older adults' task-switching ability, and this is the biggest barrier for older adults to use ICT equipment. Older adults could use ICT equipment more easily if the design did not place such a heavy load on task-switching. Therefore, compensating for the age-related decline of task-switching will help older adults to use ICT equipment. Such design improvement should promote older adults’ willingness to work using a computer, while also contributing to decreasing older adults’ decline in task-switching. However, the actual design methods that can compensate for cognitive functioning are not well developed yet. These improvements might be realized by interface design, or may require another new system function.

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